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Application of the Theory of Matrices and Vectors in Solving Economic Problems

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Since the theory of matrices and vectors is one of the main concepts of higher mathematics, they play a leading role in solving problems in other disciplines. In this article, we present that one of them is used to solve economic issues. Let's say that a car factory produces four different brands of cars in a month. If the following main characteristics of car production are given in this table by a matrix:

Product type (vehicle type)	Product quantity (pieces)	Raw material quality (tons)	Standard product preparation time (max/day)	Product price (one million in money)
1	40	6	5	60
2	60	3	3	40
3	50	7	7	80
4	70	5	6	50

General indicators for one month:

1) C - raw material quality
2) t - Working time quality
3) P - we determine the cost of product production [1]

In order to solve the mentioned problems, using the theory of vectors, we create the following vectors characterizing production based on the given main characteristics of product production:

$\vec{q}$ = (40; 60; 50;70) – assortment vector;

$\vec{S}$ = (6; 3; 7; 5) – raw material consumption vector;

$\vec{t}$ = (5; 3; 7; 6) – work time vector;

$\vec{P}$ = (60; 40; 80; 50) – price vector.

The indicators we are looking for are determined by finding the scalar product of the range vector and the remaining vectors S = qs, i.e.

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S = qs = $40 \cdot 6 + 60 \cdot 3 + 50 \cdot 7 + 70 \cdot 5 = 1120t$

Work time consumption

T = qt = $40 \cdot 5 + 60 \cdot 3 + 50 \cdot 7 + 70 \cdot 6 = 1150$ hour

And the cost of product production

P = qp = $40 \cdot 60 + 60 \cdot 40 + 50 \cdot 80 + 70 \cdot 50 = 14700$ currency

In the second type of economic problems, let the enterprise use four types of raw materials and the consumption of raw materials for the production of four types of products is given using the following matrix.

$$A = \begin{pmatrix} 3 & 2 & 5 & 6 \\ 2 & 3 & 4 & 5 \\ 7 & 3 & 4 & 2 \\ 4 & 5 & 6 & 7 \end{pmatrix}$$

Columns 1, 2, 3, and 4 are the types of raw materials used, and rows 1, 2, 3, and 4 are the types of manufactured products. If the cost of each raw material and the expenses for its transportation are 10, 12, 16, 18 and 3, 2, 1, 3 monetary units respectively, how are the following indicators determined? a) Total costs of raw materials and transportation for the production of each type of product; b) If the production plan is 80, 50, 40 and 70 units, it is necessary to determine the total costs spent on transportation of raw materials used for production. For this purpose, we construct the matrix S of the cost of raw materials used and its transportation cost [2].

$$S = \begin{pmatrix} 10 & 12 & 16 & 18 \\ 3 & 2 & 1 & 3 \end{pmatrix}$$

g) To find the total costs of raw materials and transportation for the production of each type of product, we multiply the matrix A by the transposed matrix S^{-1} that is:

$$A \cdot S^{-1} = \begin{pmatrix} 3 & 2 & 5 & 6 \\ 2 & 3 & 4 & 5 \\ 7 & 3 & 4 & 2 \\ 4 & 5 & 6 & 7 \end{pmatrix} \cdot \begin{pmatrix} 10 & 3 \\ 12 & 2 \\ 16 & 1 \\ 18 & 3 \end{pmatrix} = \begin{pmatrix} 242 & 36 \\ 210 & 31 \\ 206 & 37 \\ 322 & 49 \end{pmatrix}$$

The first column of the resulting matrix is the cost of raw materials by product type, and the second column is the cost of transportation of raw materials.

d) To find the total cost of raw materials and transportation when the production plan is given

To find the total cost of the vector plan q = (80, 60, 40, 70), it is necessary to multiply the row matrix by the AS^{-1} matrix.

$$q \cdot AS^{-1} = (80; 60; 40; 70) \begin{pmatrix} 242 & 36 \\ 210 & 31 \\ 206 & 37 \\ 322 & 49 \end{pmatrix} = (6279; 9650)$$

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62,740 elements of the resulting multiplication represent costs for raw materials and 9,650 elements represent total costs.

If five production enterprises produce five types of raw materials and produce four types of products, the small production index of these enterprises and the annual working days of each enterprise and the price of raw materials are given in the form of the following matrix, that is, in the form of a table

Product types	Enterprise productivity (product days)					Consumption of raw materials			The number of working days in a year					The price of raw materials		
	1	2	3	4	5	1	2	3	1	2	3	4	5	1	2	3
1	5	4	3	6	8	3	2	3	260	250	230	240	235	60	80	70
2	3	5	7	4	7	4	4	6								
3	6	7	6	5	0	5	5	3								
4	4	5	6	7	6	6	7	8								

Based on the given table, it will be possible to find the following. a) Annual productivity of each of the enterprises by types of production products;

b) The annual needs of each of the enterprises in terms of raw materials;

c) We are engaged in finding solutions to issues such as the annual amount of expenses spent on the purchase of raw materials in the production of products by types and quantities. We make the productivity matrices of production enterprises in the following form and denote it by A. [3]

$$A = \begin{pmatrix} 5 & 4 & 3 & 6 & 8 \\ 3 & 5 & 7 & 4 & 7 \\ 6 & 7 & 6 & 5 & 0 \\ 4 & 5 & 6 & 7 & 6 \end{pmatrix}$$

Each of the five columns in the matrix we found is the sub-productivity of an enterprise by product types, and the four row elements represent the product types, respectively.

a) To find the annual productivity of an enterprise by types of production products, it is found by multiplying the annual working days of this enterprise by the corresponding enterprise column. For example, the annual productivity of the first enterprise is 260·5; 260·3; 260·6; It is 260·4 and consists of 1300, 780, 1500, 1040. Since the annual productivity for each enterprise is found in this way, we can express the values found in the form of the following matrix.

$$A_{year} = \begin{pmatrix} 1300 & 1000 & 690 & 1440 & 1880 \\ 780 & 1250 & 1610 & 960 & 1645 \\ 150 & 1750 & 1380 & 1200 & 0 \\ 1040 & 1250 & 138 & 1680 & 1410 \end{pmatrix}$$

Now we construct the consumption matrix B of raw materials used as follows.

$$B = \begin{pmatrix} 3 & 4 & 5 & 6 \\ 2 & 5 & 6 & 7 \\ 3 & 6 & 3 & 8 \end{pmatrix}$$

The columns in this matrix represent the types of products produced, and the rows represent the types of raw materials used.

b) If we multiply the matrix B by the matrix A, we will create a matrix in which the small expenses of the enterprise are BA according to the types of raw materials.

$$BA = \begin{pmatrix} 3 & 4 & 5 & 6 \\ 2 & 5 & 6 & 7 \\ 3 & 6 & 3 & 8 \end{pmatrix} \cdot \begin{pmatrix} 5 & 4 & 3 & 6 & 8 \\ 3 & 5 & 7 & 4 & 7 \\ 6 & 7 & 6 & 5 & 0 \\ 4 & 5 & 6 & 7 & 6 \end{pmatrix} = \begin{pmatrix} 81 & 97 & 103 & 101 & 88 \\ 89 & 110 & 119 & 111 & 93 \\ 83 & 103 & 117 & 113 & 114 \end{pmatrix}$$

c) By multiplying matrix B by matrix A_{year} , we will determine the annual need for raw materials of each enterprise and write it as follows

$$BA_{year} = \begin{pmatrix} 3 & 4 & 5 & 6 \\ 2 & 5 & 6 & 7 \\ 3 & 6 & 3 & 8 \end{pmatrix} \cdot \begin{pmatrix} 1300 & 1000 & 690 & 1440 & 1880 \\ 780 & 1250 & 1610 & 960 & 1645 \\ 1560 & 1750 & 1380 & 1200 & 0 \\ 1040 & 1250 & 1380 & 1680 & 1416 \end{pmatrix} =$$

$$= \begin{pmatrix} 21064 & 24250 & 23690 & 24000 & 20680 \\ 23140 & 27500 & 27370 & 25740 & 21855 \\ 21580 & 25680 & 26910 & 26760 & 24910 \end{pmatrix}$$

It can be seen from the found matrix that its five main elements consist of the annual need of three types of raw materials of five enterprises, respectively. For example, the needs of the third enterprise for types of raw materials are 23140, 27370, 26910, respectively. The solution to the problem in the last point is if we express the raw material price matrix of the enterprise as follows and denote it by P, P = (60; 80; 70) .

By multiplying this row matrix by the BA_{year} matrix, we find the total costs of the annual stock of raw materials of each enterprise, i.e.

$$P \cdot BA_{year} = (60; 80;70) \begin{pmatrix} 21064 & 24250 & 23690 & 24000 & 20680 \\ 23140 & 27500 & 27370 & 25740 & 21855 \\ 21580 & 25680 & 26910 & 26760 & 24910 \end{pmatrix}$$

So, as a result of this multiplication, we have found the annual need for the purchase of raw materials in terms of types and quantities of the total product production of each enterprise.

In conclusion, the application of higher mathematics to solving economic problems can be cited in many ways.

In this article, we presented some applications of matrix algebra and vector algebra to solving economic problems.

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